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Role-play based Assessment of IPS²-specific Intellectual Capital

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Abstract

Due to the idea to offer costumer oriented products and services as Industrial product-service systems (IPS²) the interactions between provider and costumer become intensive. This is why IPS² are mentioned as socio-technical systems. While having direct contact to the customer staff the provider employees must be able to fulfil cross-company interactions. The challenges of such an IPS² relationship are to have the right set of competences and a useful amount of structures to handle intensive interactions and other organizational requirements. These challenges are classed with intellectual capital that characterizes intangible non-monetary values. The intellectual capital has an impact on the competitiveness of IPS² and so there is a need for a method to assess intellectual capital for IPS² relationships. In this paper an approach is shown to identify intellectual capital for IPS² relationships during the IPS² design. Also, the results of a first validation of the approach are presented that is done by a role-play- based case study.

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Keywords: Intellectual capital; IPS² Management; Intangible resources

1. IPS² as socio-technical systems

Industrial product-service systems (IPS²) are presented as relevant means to meet the challenge of global competitiveness [1] in business-to-business markets [2]. The main idea is that customers pay for the intangible utility of a tangible artifact instead of buying a product [3]. The selling of utility can be realized by an integrated offer of products and services [2]. This customer-orientation of IPS² providing companies results in a value co-creation with interactions between at least two companies. That kind of value co-creation networks are often designed as long-term business relationships. Long-term planning is connected with uncertainties due to a lack of information about future events [4]. This uncertainties can cause risks as negative events or chances as positive events und result in a redistribution of responsibilities and costs compared to traditional product buying and owning [3][4].

Contracts for value co-creation lead to networks of IPS² providers and customers. Both network partners have a greater benefit being involved in a value co-creation compared to a business model based on selling products [5]. The change of a business relationship based on selling products to selling utility is related to more intensive interactions between the employees of both partners. This is why IPS² are mentioned as socio-technical systems [2]. The social and technical aspect is illustrated by the combination of products and service offerings where services are provided by the interaction of employees among each other and with machines. These interactions are hard to be predicted during the IPS² design and engineering and therefore are part of risks for the value co-creation in IPS² relationships. Thus, to run an IPS² flawlessly the employees must be able to fulfil cross-company interactions that require social communication competences among other things. Especially, due to the fact that many employees will have a direct contact to the customer staff [6]. This include the requirements for clear assignment of responsibilities, tasks, and permissions beyond the border of just one company [7]. A further challenge at the way of transformation to provide an IPS² is that the provision of services has an influence on the organization structure. There is a need for systems that bridge over company borders

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between IPS² provider and customer [3]. These systems must consider internal and cross-company information flows that are focused on the interactions of actors to enable the IPS² offer [8]. However, the challenges in IPS² relationships based on skills, experience, organizational capabilities, and cross-company standards are barely considered in a holistic view. The negligence of at least one of the IPS² relationship based challenges is a seriously risk for an economic success [9].

This shows the need of checking which competences within the human resources are important for interactions during the daily business in IPS². Also there is a need for checking which structural requirements are important to enable a good cross-company interaction. Competences and structural requirements are parts of an intangible so called intellectual capital of companies [10]. Normally intangible resources are difficult to measure and to assess and because of that they were often ignored on the planning and designing of IPS². Otherwise intangible resources have an impact on the competitiveness of companies [11]. So, for IPS² as socio-technical systems intangible resources of both, IPS² provider and customer as well as for the cross-company relationship are crucial to provide a successful offer of utility and consequently to stay competitive. This is why the focus is set on intellectual capital for IPS² that includes intangible resources based on personal skills and based on capabilities of companies.

This paper presents an approach to assess the needed intellectual capital for IPS² relationships during the IPS² design. The approach is based on a case study with a role-play that simulates future daily routines and associated risks. For the replicability the research method is described in chapter 2. Afterwards the approach is presented in chapter 3 and its execution in chapter 4. Finally, the results of the approach are shown and discussed in chapter 5.

2. Research framework

First in this section the research question and the description of the method are presented.

2.1. Research topic

There are many ways to analyze intellectual capital. One often used method in Austria and Germany is called Intellectual Capital Statement. It is based on a structured workshop with employees of one company that first have to identify factors of intellectual capital by discussion and afterwards to assess it in a group. This method is already proved in many companies. [12]

The field of application of the Intellectual Capital Statement is an organization or a department of a company and enables the assessment of present intellectual capital. In the case of IPS² relationship the focus is on the cross-company interactions and therefore the intellectual capital that supports these interactions. A consideration of this intellectual capital is already important at the design phase of an IPS². These circumstances require more than just an adaptation of a method like the Intellectual Capital Statement. So the first task is to identify potential intangible factors that can be parts of IPS² specific intellectual capital. Subsequently an approach must be conceptualized to identify intellectual capital for interactions in an IPS² value co-creation that can be used during the designing phase.

2.2. Research method

The identification of adequate intangible factors as parts of an IPS² specific intellectual capital has been started with a literature review in the field of IPS² research. A central part has been the proceedings of the CIRP IPS² conferences from 2009 to 2014. Further, literature about intellectual capital and the method Intellectual Capital Statement has been used to cluster the results of intangible factors considering IPS² relationships.

Creativity techniques have been used due to a lack of a method to identify intellectual capital for future interactions. The result is the adaptation of role-playing games where fictive situation are described to participants and tasks have to be solved. The adaptation has to concentrate on the main value co-creating activities as well as on the risks that threaten the success of an IPS² relationship. Afterwards the feasibility of different role-playing elements has been tested through practical experiments to ensure if the approach is realizable.

3. Creation of a role-play containing daily routine in IPS²

In this section the process of creating a role-play is presented. It starts with the selection of risks and intangible factors, continuous with the creation of a plot for the daily routines, and complete with the support of the participants imagining their role and the IPS² environment.

3.1. Selection of risks

The creation of a daily routine starts with checking which risks are critical for the IPS² operation. Due to the lack of a real planned IPS² example the selection of risks is oriented on a list of 26 risks that have been found during the previous literature review. The following five risks are selected due to relevance for an IPS² operation phase:

- *Communication risks* [13]
- *Cooperation risks* [14]
- *Performance risks* [15]
- *Risk of changing requirements* [13]
- *Risk of technological progress* [15]

During the following creation of daily routines a sixth risk has been considered. It is named as *breach of contract risk*.

3.2. Selection of intangible factors

The selected risks are parts of tasks which have to be solved by participants. Afterwards the participants have to decide what kind of skills or structures has been or would have been helpful for solving the tasks. To get a higher number of results the participants can choose from a selection of intangible factors. The intangible factors utilized are based

on a guideline for the Intellectual Capital Statement method [16].

As a result of the literature review more than 180 intangible factors has been identified. Due to this high number and associated problems during a first realization of the concept the recommended intangible factors of the Intellectual Capital Statement method has been chosen [16]. Some of the factors have been adapted to the interactions in IPS². The intangible factors are clustered to categories. The categories and factors related to human skills are called Human Capital and are shown in Table 1. The categories and factors that are independent of a single person and can be related to an organization or a group of people are called Structural Capital and are shown in Table 2.

3.3. Simulation of daily routines by case studies

The approach is based on a case studies method that is used in social sciences. This empirical method is used to analyze a single example like the interaction of a group to receive representative data.

First, the roles for interaction have been chosen. This step needs an environment of an IPS² provider and a customer. The first choice of the IPS² example contains a machine for production. The design of an IPS² environment lead on to another research question about differences of intellectual capital in IPS² based on the chosen business model. According to *Tukker* and *Meier et al.* the Availability oriented business models as well as the result oriented business models are associated with increased interactions between an IPS² provider and a customer [2,17]. Therefore, two different role-plays have been designed, each for one of the two mentioned IPS² business models.

To consider the cross-company interactions a matrix has been created to check the roles with the highest amount of possible interactions. The roles chosen to concentrate on are presented in Table 3.

The design of responsibilities and tasks has been done according to the chosen roles. To validate intangible factors interactions of these roles are necessary. In an industrial case there would be no need of creating daily routines because the participants have experience about their tasks. In a case, where the participants have no such experience of daily routine, interactions are needed to enable the participants to understand where the weak points are while working together. Therefore, the creation of interactions is based on problems due to the selected risks occurring in the value co-creation.

To enable an simulation of an IPS² relationship a rough value creation chain has been built for each of the two IPS² business models. The differences between the business models concern the responsibility for the production stage using the machine of the IPS² provider. Also the IPS² offer has been created so that the participants can be familiar with it in the role-play. For this the IPS² definition of *Meier et al.* has been used that includes an integrated and mutually determined planning, development, provision and use of product and service shares [2]. Aspects of the IPS² like an onboard monitoring system and an easy accessibility design for maintenance as well as a modular design for an integration of new technology are elements that have been considered in the role-play interactions.

Table 1: Categories and factors related to human skills used for validation also named as Human Capital

Individual related intangible factors			
Professional expertise	**Social competence**	**Leadership skills**	**Employees motivation**
Ability to judge	Ability to compromise	Ability to learn & support	Relationship to superiors
Artist competence	Capability of expression	(Simulation)	Space for self-responsible
Behavior with information	Capacity for enthusiasm	Entrepreneurial actions	actions
Conversation techniques	Capacity of reaction	(Innovation)	
Coordination	Conflict management skills	Fairness	
Customer oriented	Cooperation	(Respect, appreciation)	
competences	Creativity	Leading by example	
Ecological understanding	Cross-company team	(Identification)	
Industry expertise	understanding	Multicorporate	
Interdisciplinary	Empathy	Leadership Skills	
competences	Flexibility	Objective & perspective (Inspiration)	
Logical thinking in cross-company	Improvisation skills	for others	
context	Intercultural competence	Result-oriented directives	
Management competences	Multidisciplinary Communication	(Enabling)	
Market know-how	Skills	Transparent instructions	
Organizational talent	Organizational skills		
Spatial sense	Personal responsibility & self-		
Technical competence /	dependence		
Understanding	Reliability		
	Self-reflection		

Table 2: Categories and factors related to an organization or a group of people used for validation also named as Structural Capital

Company related intangible factors			
Management tools	**Information Technology and documented knowledge**	**Cooperation & knowledge transfer**	**Corporate culture**
Appraisal system	Communicated & accepted standards for information processing	Multicorporate Cooperation and Knowledge Transfer	Activities to improve Relationship of colleagues
Coaching / Mentoring		Portfolio & participants of cooperation projects	Codes of conduct for transparency & fairness
Competence profiles	Cross-company Management Tools	Regularly, interdepartmental meetings	Collaborative cause analysis
Continuous improvement process	Document management	Spontaneous, interdepartmental meetings	Motivate to appeal mistakes without having to face with consequences
Cross-company & division related result planning	IT infrastructure for acquisition of information		Open communication culture
Cross-company training	IT support for optimal use		Procedure for an easy convey of decisions
Definition of areas of responsibility	IT-infrastructure for communication		Promotion of cross-company cooperation
Management by objectives	Multicorporate Communication Structure		Setting an example of values & working culture
Mediation of a cross-company portfolio & potentials overview	User friendliness of IT support		
Rules for structured written communication			
Standards for meetings, workshops & events			

Resumed, the creation of the role-play contain the choice of participating roles, their responsibilities, an IPS² offer according to the chosen IPS² business model, and a rough environment. This includes the preparation of information leaflets and presentation of the environment. One major challenge is the balance between written information and narrated information to keep the participants' attention.

4. Execution of the case studies

In this section the process of executing the role-play based case study is presented.

4.1. Participant structure

The requirements to the participants are slipping into the given role, solving the given tasks by interacting with other roles, and considering the IPS² environment as well as the IPS² business model. Due to these requirements the participants should be familiar with IPS² and the associated business models. For that reason researcher in the field of IPS² are appropriate candidates as participants to validate the approach.

The case study is designed for four roles in each IPS² business model case. 15 researchers have accepted to participate in the role-play. According to *Boehm and Thomas* three of the 15 participating attendees are the most productive authors in the field of IPS² research [18]. Three of the participants are professors, four are working as associate professors, seven participants have been research assistants, and one participant has been a student. Also, two participants have intensive connections to industrial companies interested in IPS². Further, the cultural background of the participants has been distributed to the countries Japan (5), Sweden (4), Germany (3), France (2), and Italy (1).

4.2. Execution and valuation method

At the beginning of the roll-play, the participants have got a presentation of two fictional companies. This should help to imagine and understand the circumstances. The participants have been divided into two groups. One group has started with the role-play that took an availability oriented IPS² business models as a basis. The other group has started with the role-play based on a result oriented IPS² business model in parallel. With one exception two participants have shared one role. Then, the role specific tasks have been distributed and the participants have received sufficient time to read them. After solving the tasks in the role-play an individual and group validation have started. This complete procedure has been repeated for a second role-play where the groups have done the other role-play.

The validation of the intangible factors has taken place directly after the role-play. At first, the participants have to write down intangible factors that are specific to individuals. For this there have been no given factors. Then, there have

Table 3: Roles and task descriptions for the participants of the role-play

IPS² provider		**IPS² customer**	
Role	**Tasks Description**	**Role**	**Tasks Description**
Technology manager	Detection of potentials and utilization of new technologies	Production manager	Operation scheduling; Coordination with IPS² provider
IPS² process manager	Execution of the IPS²: Planning and implementation of the offered service & product components	Research and development manager	Development of new products and solution; Cooperation and coordination with development partners

been the same validation for company specific intangible factors. After the individual assessment a validation done by the group has followed. Here, the participants could choose the given factors presented in Table 1. These factors have to be structured in a diagram with the axes “Importance” and “Relevance for IPS²”. The same group validation has been repeated for the factors of Table 2.

Both groups have been done the role-play with the validation in parallel to reduce the mutual influence.

5. Results

The results of the individual validation done by form sheets and the validation in groups are presented in Figure 1 and Figure 2. The results are sorted by the number of individual indications. Also, only the intangible factors are shown that have been given by at least two participants or have a total amount of group and individual indications of three. The preference of the individual indications is due to the influence of few individuals on a whole group result. The indications of both participants groups are condensed relative to the result or availability oriented role-play. Due to the fact that all 15 participants have done both role-plays the maximum amount of individual results is 30. The maximum amount of group results is four based on two groups that respectively validated two role-plays.

One interesting result has been the indication of negotiation skills. This factor has not been planned for the group validation wherefore this can be an explanation why there are no group indications. However, there has been the possibility to add new factors for the group validation, what have been used for the factors low hierarchies and requirement specification. Although the factor (negotiation skills) has been noted on the form sheets by six participants, no one has added this factor in the group validation. Furthermore, many of the factors seem to have general importance for IPS². Some factors have a drift to be more important for the result oriented IPS² business model based role-play like interdisciplinary competences, management competences, conflict management skills, promotion of cross-company cooperation, and mentoring. Others have the trend to be specific for the availability oriented IPS² business model based role-play like technical competence and understanding, empathy, transparent instructions, IT-infrastructure for communication, and multicorporate cooperation and knowledge transfer. Nevertheless, these results just show characteristics of intangible factors that have been validated as important for fictive IPS² daily routine situations. However, it shows that a simulation of risks in case studies method is a possibility to identify intangible factors that have to be regarded by planning an IPS². Furthermore, emphases trends of intangible factors are visible. For human skills based factors general interdisciplinary skills and the handling of the costumer and its staff have a high share of the results. The intangible factors related to companies are dominated of communication and knowledge transfer. Of course, technical communication solutions are still regarded while planning IPS², but factors like regular meetings and an open communication culture cannot be planned and implemented like new technical components.

6. Conclusion

With the help the participants it could be shown that an abstract IPS² daily routine can be simulated by role-plays with objectives concerning a management of tasks. Different kinds of conflicts as parts of risks, like emotional conflicts could be expressed and solved. The participants have followed the task instructions completely except one case where the scope has been got around in a creative way. According to the feedback the participants could identify with their role in a short time. This has been reflected in the high number of intangible factors given in the individual validation, too.

The presented results show first trends to answer the research topic which intangible factors have a specific importance for IPS². These factors can be important for the

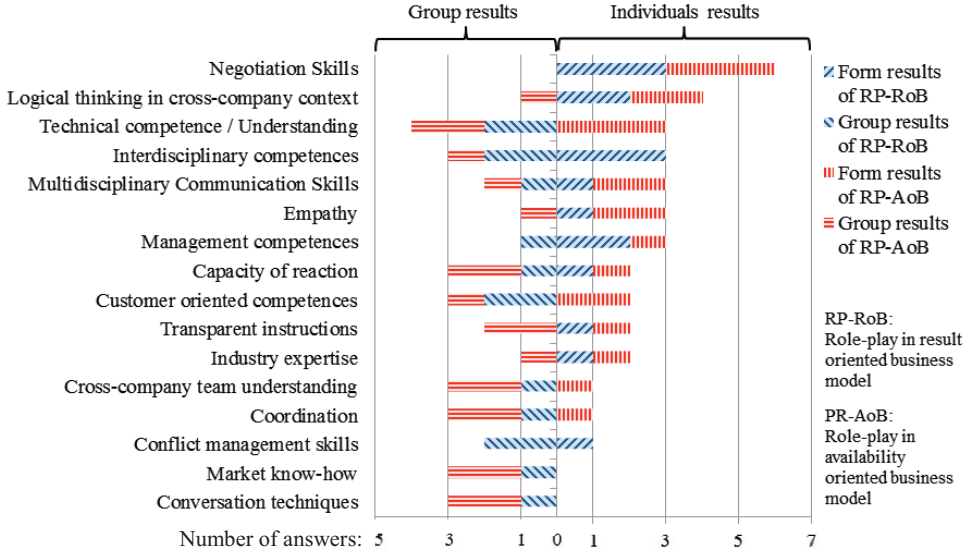

Figure 1: Results of individual and group indications of intangible factors related to human skills

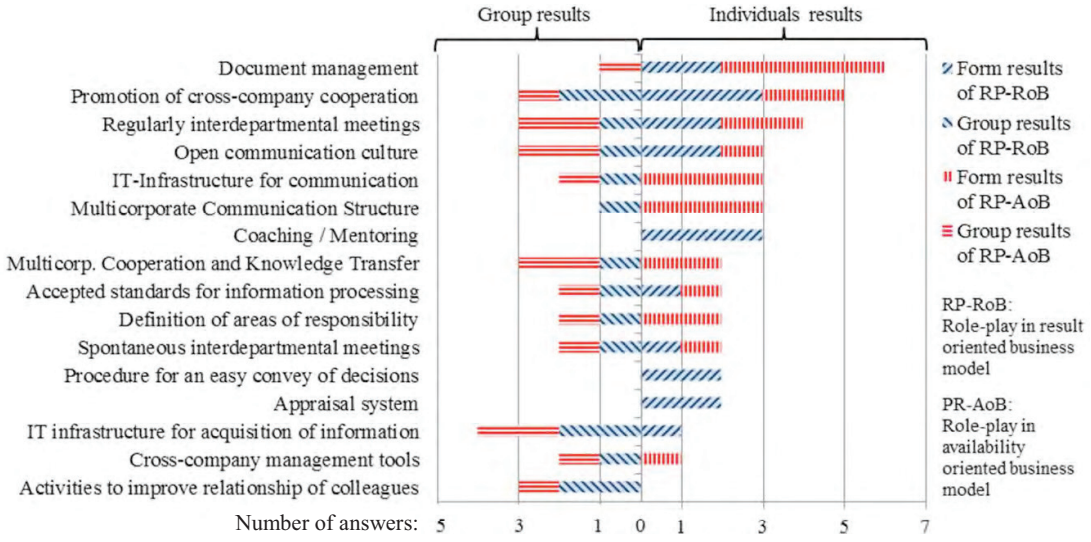

Figure 2: Results of individual and group indications of intangible factors related to organizations

success of value co-creation and need long-term methods to implement them in a sustainable manner.

In principle the first validation shows that the presented approach is feasible to identify intangible factors to reduce risks in IPS². Anyhow, there is a need for further validation of the approach.

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